IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Uri Cohen Confirmation No. 2289

Serial No.: 10/688,333 Filed: 10/17/2003

Grp. Art Unit: 1742 Examiner: Wilkins III, Harry D.

Title of Application: Methods and Apparatus for Activating Openings for Jets Plating

CERTIFICATE OF MAILING under 37 C.F.R. 1.8(a)

I hereby certify that this correspondence is being deposited on December 19, 2006 with the United States Postal Service as first class mail, with sufficient postage, in an envelope addressed to Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Uri Cohen, Applicant

December 19, 2006
Date of Signature

Mail Stop Amendment
Commissioner for Patents
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Declaration Submitting Evidence Under 37 CFR 1.132

1. I, Uri Cohen reside at 4147 Dake Avenue, Palo Alto, California 94306, am the inventor of the inventions disclosed in a patent application having Serial No. 10/688,333, which patent application was filed on October 17, 2003 and which patent application has a priority date of November 5, 2002, and I declare the following:

2. Prior to the priority date, I carried out experiments concerning jets electrofilling of very deep (30-95μm), blind vias in substrates with copper metal.

3. I obtained from a Japanese Consortium several 200 mm silicon wafers which included die patterns. Each die pattern consisted of several arrays of (mostly) square, blind vias which were etched into the 200 mm silicon wafers to provide vias having different widths, depths, and aspect ratios. The top surface of the wafers, including the sidewalls and bottom surfaces of the vias, were coated with a sputter-deposited, copper seed layer (before I obtained the wafers).

4. I created the substrates by cutting pieces from the silicon wafers --each piece included roughly one die pattern. Next, the pieces were jets-electroplated with copper. Figures 1A and 1B show typical portions of arrays of 15μm wide (Figure 1A) and 50μm wide (Figure 1B) square vias after copper jets-electroplating --Figures 1A and 1B (in Exhibit A) are scanning electron microscope (SEM) photographs taken by Riga Analytical Laboratory ("Riga") at a 30°tilt angle to the top surface of a substrate. These photographs show both the top surface and a (cleaved) cross-section surface of the substrate.

5. The jets-electroplating experiments were carried out in a jets-electroplating cell similar to the one shown in Figure 1 of the present patent application. The acidic copper electrolyte consisted of 10% (v/v) H_2SO_4, 0.3 M $CuSO_4$, 50 ppm Cl^- ions, and two commercial additives ("Ultra Fill") supplied by Shipley Company. The jets pressure was 40 psi, the flow rate was 3.8 GPM, the anodes/jets assembly was rotated at 20 RPM, and the bath temperature was about 25°C.

6. I have attached, as Figures 2A-2D (in Exhibit A), four (4) SEM photographs of (cleaved, epoxy mounted, and polished) cross-sections of sample #192 which I electroplated in one experiment. This (cut piece or die) sample was: (a) pre-activated for 2 minutes in a slowly agitated 10% (v/v) sulfuric acid; (b) rinsed in deionized water; (c) dried; and (d) activated again for two (2) minutes in jets of the acidic copper electrolyte (in the jets-electroplating chamber) prior to commencing the jets-electroplating. The sample was then jets-electroplated at a (nominal) current density of 30 mA/cm^2 for 30 minutes, rinsed in deionized water, and dried. I then took the sample to Riga where the sample was cleaved, mounted in an epoxy mold, and polished. Riga then took SEM photographs of the mounted and polished cross-sections. Observations of several SEM photographs (Figs. 2A-2D in Exhibit A) of sample #192, provided the following data which is displayed in Table I below: via dimensions (width, depth, and aspect ratio), along with the observed wetting (or penetration) depth of the electrolyte (determined by the extent of plating on the sidewalls from the top, and indicated by horizontal arrows in the figures), and the fraction (in %) of the penetration depth relative to the total depth of the vias.

Table I

Figure	Via Width (μm)	Via Depth (μm)	Via Aspect-Ratio	Wetting Depth (μm)	Wetted Depth Fraction (%)
2A	55	93	1.69:1	44.3	48
2B	17	74	4.35:1	37.2	50
2C	9	52	5.78:1	45.0	~87
2D	6	52	8.67:1	52.0	~100

7. As a result of those experiments (see Figs. 1A-1B and 2A-2D), I discovered that the very deep blind vias failed to be filled properly with electroplated copper. However, after I further examined the results presented in Table I, I discovered, unexpectedly and surprisingly, that the extent of electrolyte penetration and plating into the blind vias (see column 5 in Table I, and the horizontal arrows in Figs. 2A-2D) was better in the narrower and higher aspect ratio vias than in the wider and lower aspect ratio vias (see column 2 in Table I). In addition, I discovered that the difference between the results for narrower vias and wider vias was even more apparent when the wetted depth (from the top) was considered as a fraction of the entire depth of the vias (see column 6 in Table I).

8. My conclusions from the above data are: (a) the extent of wetting inside narrower and higher aspect ratio deep openings is further and better than in wider and lower aspect ratio openings, and (b) the lack of wetting inside the wider and lower aspect ratio deep openings is likely due to insufficient capillary forces.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

12/19/2006
Dated

Uri Cohen, Applicant

Attachment: Exhibit A consisting of six (6) SEM photographs.